ET 153154505 US

Low Force Electrical Contact

BACKGROUND OF THE INVENTION

This application claims the benefit of priority of Provisional Patent Application SN 60/252,801 that was filed on November 22, 2000.

This application is related to a pending patent application entitled "Electrical Contact", by the same inventor, application serial number 09/916,749 filed on July 27, 2001, which application claims the benefit of Provisional Patent Application SN 60/221612 that was filed on July 28, 2000. This co-pending patent application, in its entirety, is incorporated by reference herein.

1. Field of the Invention:

The present invention, in general relates to electrical contacts and, more particularly, to electrical contacts that provide minimal insertion-removal force and which are tolerant of axial misalignment of the contacts.

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DETAILED DESCRIPTION OF THE INVENTION

Referring now in particular to **FIG. 1** is shown a prior art type of a socket 2 and a pin 4 disposed therein, identified in general by the reference numeral 5. The pin 4 makes contact with each of the tines 6 along a substantial portion of the length of the pin 4.

This mechanical geometry requires that the center longitudinal axis of the pin 4 align precisely with the center longitudinal axis of the socket 2, else insertion of the pin 4 into the socket 2 become especially difficult.

In short, the prior art design is intolerant of axial misalignment between the pin 4 and the socket 2.

The prior art design is also based on the long-held belief in the electrical connector arts that for high current applications, a maximal area of contact is preferred. In accordance with prior contact design theory, it is believed that maximum contact area is required for high current loading and that a lesser area would result in a higher temperature rise.

Experimentation has shown, however, that the opposite is true, and that the prior art types of designs tend to experience a greater rise in temperature than the instant invention.

Referring now to the remainder of the **FIG.** drawings, and in particular to **FIG. 2** is shown a side view of a socket, identified in general by the reference numeral 10, as is used with the present low force electrical contact. **FIG. 3** is a cross sectional view of the socket 10 of **FIG. 2**.

The socket 10 is of any preferred size and, although only one is shown, a plurality of sockets 10 are typically used in a socket half portion of a connector (not shown). The use of a plurality of sockets 10 to form a plurality of electrical connections is well known by those possessing ordinary skill in the electrical arts.

The socket 10 includes an insulator tip 12 that is disposed over a hood 14 at a first end thereof. A second opposite end of the hood 14 is disposed around a socket contact 16.

The socket contact 16 extends to the rear of the socket 10 and is adapted for attachment to a wire (not shown).

Methods of attaching the socket 10 to the wire are well known in the art. One preferred method of attachment includes crimping of the socket contact 16 around the wire and another common method includes soldering the wire to the socket contact 16. Any preferred method may be used.

Referring now to **FIG. 4** an enlarged cross-sectional view of the nose portion of the socket of **FIG. 3** is shown. A pin 18 is disposed proximate the socket 10 and prior to the mating of the two together. A pin half of a connector 19 (i.e., that portion that houses the pin(s) 18 mates with the socket half of a connector (that portion that houses the socket(s) to complete the electrical connection).

A plurality of tines 20 are provided which are electrically and mechanically mated with the socket contact 16 or a portion thereof. Each of the tines 20 are separated by a slot 22 that is disposed intermediate each tine 20. Each slot 22 (four if four tines 20 are used) extends substantially the longitudinal length of the tines 20. Therefore, the socket 10 is generally of the type that is commonly referred to as a "split-tine".

The tines 20 are formed of a high yield strength type of conductive metal and therefore have an ability to spring

back into position. Therefore, the tines 20 need not be set inward nor are external helper springs required to produce a normal force (i.e., a force applied to the tines 20 that urges the tines 20 toward the center of the socket 10 and which helps to ensure electrical conductivity when the pin 18 is mated with the socket 10), as is described in greater detail hereinafter.

Each of the tines 20 includes a first stage, identified in general by the reference numeral 23, that is disposed adjacent the socket contact 16 portion with which it is in electrical contact. The slot 22 intermediate each of the tines 20 terminates in the first stage 23, near the socket contact 16 portion. Accordingly, the tines 20 are each joined together in a common area of the first stage 23 proximate the socket contact 16.

An inner shoulder 24 tapers outward as does an outer shoulder 25 which, together, transition the tine 20 into a second stage, identified in general by the reference numeral 26. The second stage 26 extends from the inner shoulder 24 toward the insulator tip 12 and is thinner than the first stage 23. The second stage 26 terminates at a tip 21 of the tine 20.

Accordingly, the first and second stages 23, 26 of each tine 20 function as a two stage spring that tends to supply the necessary normal force to urge the tip 21 of the tine 20, generally, a limited amount toward the center of the socket 10. The high yield strength metal allows each stage 23, 26 of the tine 20 to function as a more capable and durable spring.

The tines 20 are machined so as to provide a natural offset of the tip 21 toward the center of socket 10 (i.e., away from the hood 14). This ensures that when initial contact of the pin 18 is made with the tine 20, that it is the tip 21 of the tine 20 that first makes contact with the pin 18. This is described in greater detail hereinafter.

The first stage 26 adds compliance (i.e., an ability to flex within the normal operating range of the first stage 26 as a spring). This is useful to protect the socket 10 from permanent deformation or loosening in response to side loads that are inflicted by the pin 18 upon the tines 20 when a rocking motion is used to insert the pin half of the connector 19 into the socket half of a connector.

The hood 14 limits the maximum radial extension that is possible for each tine 20, thereby ensuring that not even an

excessive rocking motion by the pin(s) 18 can displace the tines 20 so far that any of them can become permanently deformed or loosened. Accordingly, the ability to apply a normal force by the tip 21 of the tine 20 upon the pin 18 for the useful life of the socket 10 is ensured.

In the unmated state, the outside diameter of the tines 20 is less than the inside diameter of the hood 14, which provides a gap 28 therebetween.

The outside diameter of the tines 20 is also tapered, so that when the socket 10 is fully mated with the pin 18, the outside profile of the tines 20 becomes nearly cylindrical along the entire longitudinal length thereof (See **FIG. 5**). This provides a minimal clearance (i.e. the gap 28) in the mated state between the outside of the tines 20 and inside diameter of the hood 14. This, in turn, constrains the tines 20 and prevents them from loosening. The hood 14 is preferably formed of a metallic material.

Referring now also to **FIG. 5**, the inside diameter of the second stage 26 of each tine 20 is machined with an area that is undercut 29 beginning a predetermined distance inward from the tip 21. The undercut 29 extends in a

direction toward the socket contact 16 and terminates at the inner shoulder 24.

This makes each of the tines 20 thicker proximate the tip 21 and it creates a "patch" of contact, identified in general by arrow 30. The patch 30 of each tine 20 is that portion of the tine 20 that makes initial contact with the pin 18 during mating. The patch 30 is maintained during the entire mating/unmating cycle.

It is also apparent that because contact occurs primarily at the patch 30 proximate the tip 21 of each tine 20, the entire length of the tine is utilized as a two-stage spring member and allows for higher normal forces to be designed into the socket 10 while minimizing any chance that side loads will result in permanent yielding.

An additional benefit that is provided is that proper normal force, and therefore electrical contact integrity, is established early on in the mating stroke and is maintained even after partial unmating has occurred.

There is another significant benefit that is provided by this configuration. As stated hereinabove, the normal force is provided by each tine 20, which functions as a long

two stage spring. The distance the tip 21 of the tine 20 moves radially upon mating is the amount of "spring travel" and this, for any given size of the socket 10, is relatively large.

Accordingly, the normal force that is provided is less dependent on variations of the outside diameter of the pin 18 and the inside diameter of the socket 10 that are caused by either machining tolerances or wear over time. Having less critical tolerances decreases manufacturing cost. A more constant normal force that is less affected by wear helps to provide a reliable long lasting electrical contact.

Because the normal force that is provided is less subject to variation, so too are the mate and unmate forces less dependent upon tolerances or wear. Similarly, the voltage drop that can be expected to occur intermediate the tine 20 and the pin 18 is less dependent upon tolerance or wear.

During insertion and removal of the pin 18 from the socket 10, each tine 20 wipes the pin 18 along the patch 30. This helps to remove oxidation from either the pin 18 or the patch 30, thereby ensuring low electrical resistance and optimum current flow. The patches 30 effectively utilize the

normal force that is supplied by the spring action of the tines 20 to maximize the contact force.

If there are four tines 20 in the socket 10, then there would ~~be four patches 30~~ in the socket 10, each patch 30 of which is adapted to provide positive electrical contact intermediate the tines 20 and the pin 18 and to do so at a higher pressure (for any given normal force than prior art designs) being applied to the pin 18 by the tines 20.

Furthermore, due to the geometry provided, it can now be controlled and therefore predicted where electrical contact will physically occur and therefore where current flow will occur. It will occur primarily along the patch 30 of each tine 20 and primarily toward the tip 21 of each tine 20.

If desired, the patch 30 can be modified to vary the areas of contact that occur with the pin 18. One of these methods is disclosed in greater detail in related co-pending patent application that was filed on July 27, 2001, serial number 09/916,749 by the same inventor and which has been incorporated by reference herein.

For example, if the patch 30 area of each of the tines 20 is modified and machined so as to include an inside radius that is less than the outside radius of the pin 18, contact with the pin 18 would occur intermediate each tine 20 and each pin 18 along two lines of contact that are in parallel longitudinal alignment with the pin 18 and which are disposed along two outer edges of the patch 30. See **FIG. 7** of the above-identified related application.

Then, during insertion and removal of the pin 18 from the socket 10, each modified tine (not shown) would wipe the pin 18 along its two outer edges. Those edges would effectively utilize the normal force supplied by the spring action of the modified tines to maximize the contact forces that occur by concentrating them.

If there are four modified tines in the socket 10, then there would be eight edges of contact (with the pin 18) in the socket 10, each edge of which is adapted to provide positive electrical contact with the pin 18 and to do so at a higher pressure (in pounds per square inch) for any given normal force than would otherwise be possible.

Furthermore, the lines of electrical contact would be predicted to occur along the edges. The edges would also

serve to mechanically wipe the contact surfaces, thereby removing oxidation that forms on either the pin 18 or on the edges of the patch 30 or both.

The electrical contact that is provided by the edges would also serve to create two parallel lines of current flow (for each modified tine) that are optimally configured to run longitudinally inward and up the modified tine, exactly as is physically desired.

This preceding discussion is intended to show that additional and further modifications can be made to the instant invention, as desired, without departing from the spirit and scope.

Referring once again to the drawing figures, the pin 18 of **FIG. 5** includes a first longitudinal center axis 32 that does not align with a second longitudinal center axis 34 of the socket 10. For this to occur either one or both of two conditions must occur.

One such condition occurs when the pin half of the connector 19 is rocked side to side. The undercut 29 provides clearance for a nose portion 18a of the pin 18 to move sideways without contacting the interior of the tine

20. This tends to keep insertion and removal forces low, even if the pin half of the connector 19 is rocked during insertion or removal.

The other condition that results in misalignment of the first longitudinal axis 32 with respect to the second longitudinal axis 34 occurs when a plurality of pins and sockets are included in the connector and all of them do not share parallel axes. The reasons why this can occur were discussed in greater detail hereinabove in the BACKGROUND OF THE INVENTION section of the specification.

It does not matter if the misalignment is caused by certain of the pins 18 or certain of the sockets 10, or both. When a plurality of electrical contacts occur in a given connector and there are any pins 18 or sockets 10 that do not have parallel axes, a misalignment of the first and second longitudinal axes 32, 34 will occur.

The undercut 29 allows the pin 18 to mate with the patches 30 and provides clearance for the nose of the pin 18a as it enters into the socket 10 when axial misalignment occurs. The undercut 29 prevents excessive displacement of the tines 20 from occurring under such conditions which in

turn prevents a substantial increase in insertion or removal force from occurring.

In a prior discussion, an example was provided where six contacts normally experience (by themselves) an insertion force of ten pounds per contact but where the total insertion force is ninety pounds (not sixty) due to misalignment of the axes 32, 34.

According to the instant invention, an angular misalignment 36 up to approximately three degrees can be accommodated without incurring a substantial increase in insertion (or withdrawal) force.

When the pin 18 is fully inserted into the socket 10, each slot 22 expands accordingly to accommodate the radial extension of each tine 20. When fully inserted, the pin 18 does not enter into the socket 10 beyond the first stage 26 of the tines 20.

The invention has been shown, described, and illustrated in substantial detail with reference to the presently preferred embodiment. It will be understood by those skilled in this art that other and further changes and modifications may be made without departing from the spirit

and scope of the invention which is defined by the claims appended hereto.

What is claimed is: